Integrated damper suspension system

SPECIALIST IN HIGH PERFORMANCE SHOCKS
Introduction

- Vehicle dynamics and damping
- Converting kinetic energy into Thermal energy
- Controlling extension stroke of the suspension
Integrated suspension/damping system

- Damping important part of suspension working
- In harmony with other important components
- Tire, Damper, Spring, unsprung mass
- Sprung mass
- Anti roll bar
- Sprung mass varies under dynamic conditions
Over riding factors

- Exceptional high spring rate
- Too strong anti roll bar settings
- High rebound damping forces at low velocity
- Friction
Damping a mysterious component?

- Damping force generated by combination of
  - Orifices, valves, fluid, displacement and velocity
  - Larger displacement is better against fade
Adjustments

- Bad handling, understeer, oversteer
- Traction, Grip not cured by stronger rebound force
- Importance of compression damping not always understood
Dynamometer readings

- Dyno usefull piece of equipment
- Dyno forces damper through velocity range
- Recorded in force velocity graph or force displacement graph
- Damper in suspension does not follow exact line
- Responds to input from suspension resisting movement
Dyno curves
Damping characteristic

- Damping characteristic not cast in stone
- More ways to realize the correct damping curve
- Drivers have different opinions
- One goal, a perfect handling car
Effect of damping

- Damping characteristic design, not a black art.
- Dampers respond to laws of physics.
- Damping force in range from 0 to 5 cm/second piston velocity more effective.
- High speed damping less important.
Twin tube design damper

- worked well but had restrictions.
- Had to be mounted vertical.
- Not suited for horizontal installation without modification.
Low pressure twin tube gas damper

- Design improvement over twin tube
- Gas pressure replacing the baric pressure
- Better ride qualities for road cars
- Still not very useful for race applications
External adjustable twintube damper

- Big step ahead
- Could be adjusted on the car
- With external reservoir transformed performance
Single tube gas damper

- Single tube gas damper better performance.
- Packaging restrictions because of axial gas reservoir.
- Piston rod restricted in diameter of 12 mm.
- 20 bar of gas pressure needed.
- Larger piston rod would displace too much fluid.
- Mcpherson strut needs large piston rod.
Cutaway single tube damper
New approach to damping

- Fresh look at damper design and operation
- Critical look at existing ways
- Design combination adjustable damper / gas spring
- Scaled down damper do not work well
- More fluid displacement needed
- Damper most effective at 0 to 5 cm piston velocity
External reservoir, compression valving
**External reservoir**

- Compression damping valving in reservoir.
- Low and high speed adjustment independent.
- Single tube damper functions in compression as twin tube damper.
- Shim stack on top of piston not necessary for compression damping.
- Gas pressure not needed for damper operation in compression.
- Gas pressure variation used as suspension support.
Gas pressure supporting the suspension

- Suspension moved less by 50% with gas support.
- Car could run lower, better use of aero dynamics.
- Spring rate can be built in by varying gas volume according to Boyle's law $PXV = C$. 
Gas force positive effect compression stroke

- 20 bar pressure provides 75.8 kg support or lift.
- Damping function does not depend on gas pressure.
- Gas pressure is variable from 6 bar to 25 bar.
- Gas support runs parallel on spring rate.
- Spring rate can be lowered.
- Lower natural frequency good for traction.
Spring rate graph, gas force

[Graph showing compression (kg/cm) vs. force (kg) with different lines for Gas pressure, Spring rate, Cor. Gas pressure, and Cor. Spring rate.]
Damping the unsprung mass

- Damping unsprung mass big gain.
- Unsprung mass moves with higher frequency.
- Most underestimated cause for bad handling.
- Tire road contact is much better with gas lift.
- Lap times do not deteriorate during race.
- Increase in grip levels.
- Gas pressure as tuning tool, very effective.
Wide range of support

- Gas pressure force at 5 bar is 18.95 kg.
- Gas pressure force at 25 bar is 94.72 kg.
- Pressure can be varied without adverse effects.
- Gas pressure supports outside wheel in corner.
- Left and right operate independently.
- Less suspension travel in compression.
Most significant improvement in handling

- Daytona 24 hour test days 2008.
- No results with conventional way.
- Heavy understeer, low grip levels.
- Increased gas pressure, compression damping.
- Fastest lap of the day and P1 of GT.
Mechanical grip

- Improvement in handling due to mechanical grip
- Basis for good handling
- Handling less dependent on aero dynamics
- Report race engineer